

Wireless Digital Communication





- Modern electronic devices like PCs, tablets, and smart phones all have numerous communication systems built-in.
- The aim of this presentation is to identify these systems and explain their different capabilities.
- The topics to be covered are:
 - Cellular networks
 - Wi-Fi
 - Bluetooth
 - Near Field Communication (NFC)
 - GPS

Cellular Networks



- A cellular network or mobile network is a wireless communication network distributed over land areas called "cells", each served by at least one fixed-location transceiver or base station.
- These base stations provide the cell with the network coverage which can be used for transmission of voice, data, and other types of content.
- A cell typically uses a different set of frequencies from neighbouring cells, to avoid interference and provide guaranteed service quality within each cell.
- When joined together, these cells provide radio coverage over a wide geographic area.


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- This enables numerous portable transceivers (e.g., mobile phones, tablets and laptops equipped with mobile broadband modems, pagers, etc.) to communicate with each other and with fixed transceivers and telephones anywhere in the network, even if some of the transceivers are moving through more than one cell during transmission.
 - Cellular networks offer a number of desirable features:
 - More capacity than a single large transmitter, since the same frequency can be used for multiple links as long as they are in different cells.
 - Mobile devices use less power than with a single transmitter since the cell towers are closer.
 - Larger coverage area than a single terrestrial transmitter, since additional cell towers can be added indefinitely and are not limited by the horizon.

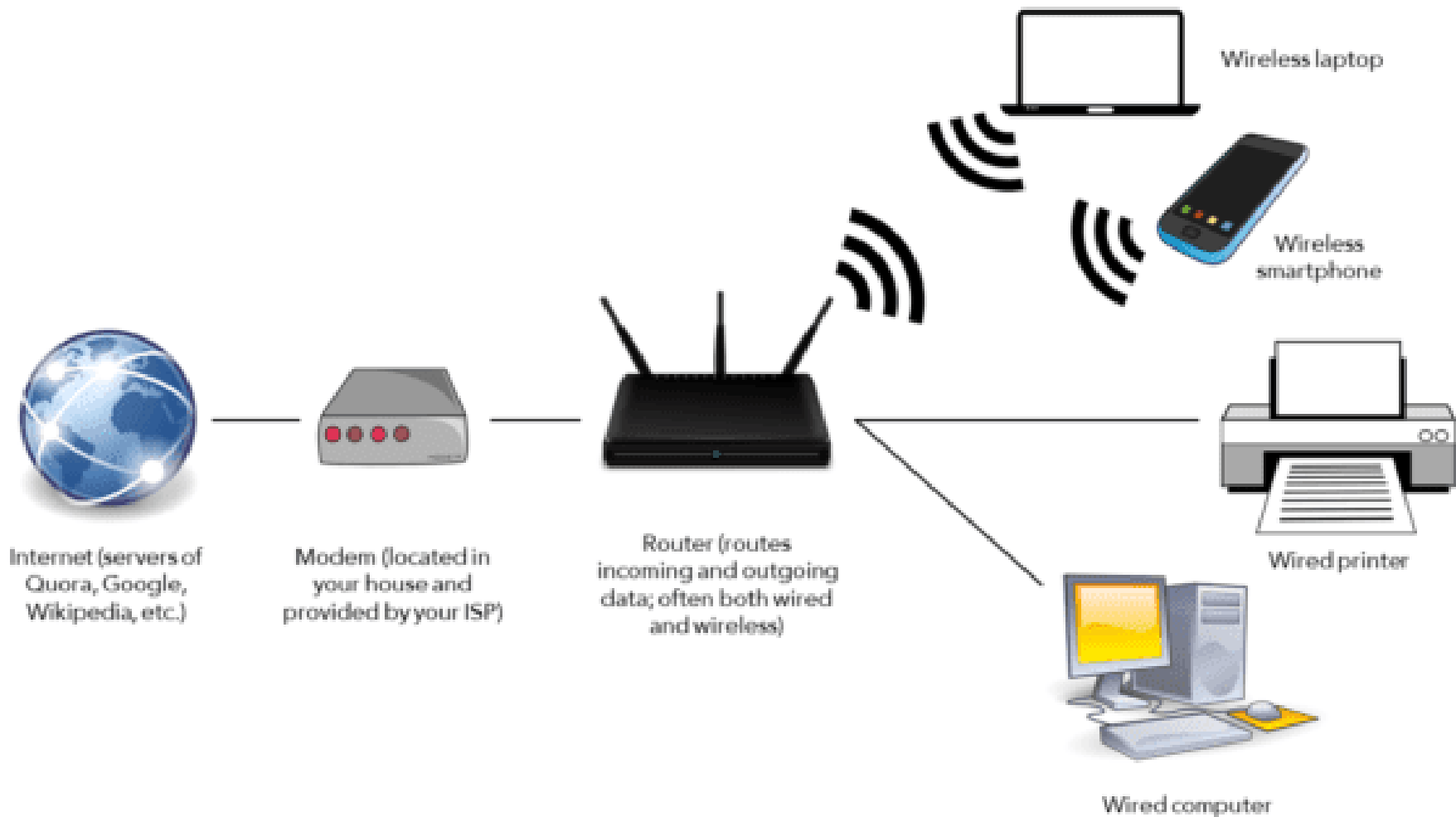
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- The technology used for cellular networks has evolved over time with each new generation giving greater data rates and capacity.
 - As new generations are implemented, older ones are phased out to allow re-use of the radio spectrum.
 - Fourth generation is 4G, etc.
 - 4G is more spectrally efficient than 3G, just as 5G is more spectrally efficient than 4G. Each generation delivers more data per hertz than the previous one. 3G works at frequencies up to 2.1 gigahertz, 4G up to 2.5 gigahertz and 5G can be up to 95 gigahertz.
 - As the frequency increases the signal is more easily obstructed or attenuated by obstacles. More 5G antennas will need to be installed to support the reliability of the network. However, as these are smaller and don't require a tower they can be placed on buildings and lampposts, for example.

Wi-Fi




- Wi-Fi is a family of wireless network protocols, based on the IEEE 802.11 family of standards, which are commonly used for local area networking of devices and Internet access.
- These are the most widely used computer networks in the world, used globally in home and small office networks to link desktop and laptop computers, tablet computers, smartphones, smart TVs, printers, and smart speakers together, and to a wireless router to connect them to the Internet.
- Also used for wireless access points in public places like coffee shops, hotels, libraries and airports to provide the public Internet access for mobile devices.

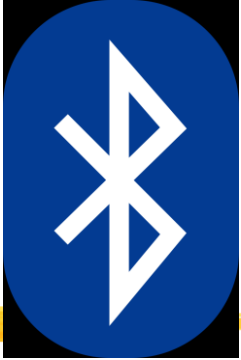
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- Wi-Fi uses multiple parts of the IEEE 802 protocol family and is designed to interwork seamlessly with its wired sibling, Ethernet.
 - Compatible devices can network through wireless access points to each other as well as to wired devices and the Internet.
 - Wi-Fi most commonly uses the 2.4 gigahertz (120 mm) UHF and 5 gigahertz (60 mm) SHF radio bands; these bands are subdivided into multiple channels. Channels can be shared between networks but only one transmitter can locally transmit on a channel at any moment in time.
 - The higher frequency is faster but has a shorter range and is more easily blocked.
 - 5 gigahertz wi-fi has the potential to be confused with the 5G cellular spectrum.




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- Wi-Fi uses a large number of patents held by many different organizations. The CSIRO may not have invented Wi-Fi but it developed technology that made it practicable.
 - In April 2009, 14 technology companies agreed to pay Australia's CSIRO \$1 billion for infringements on CSIRO patents.
 - CSIRO won a further \$220 million settlement for Wi-Fi patent-infringements in 2012, with global firms in the United States required to pay CSIRO licensing rights estimated at an additional \$1 billion in royalties.
 - In 2016, the CSIRO wireless local area network (WLAN) Prototype Test Bed was chosen as Australia's contribution to the exhibition A History of the World in 100 Objects held in the National Museum of Australia.

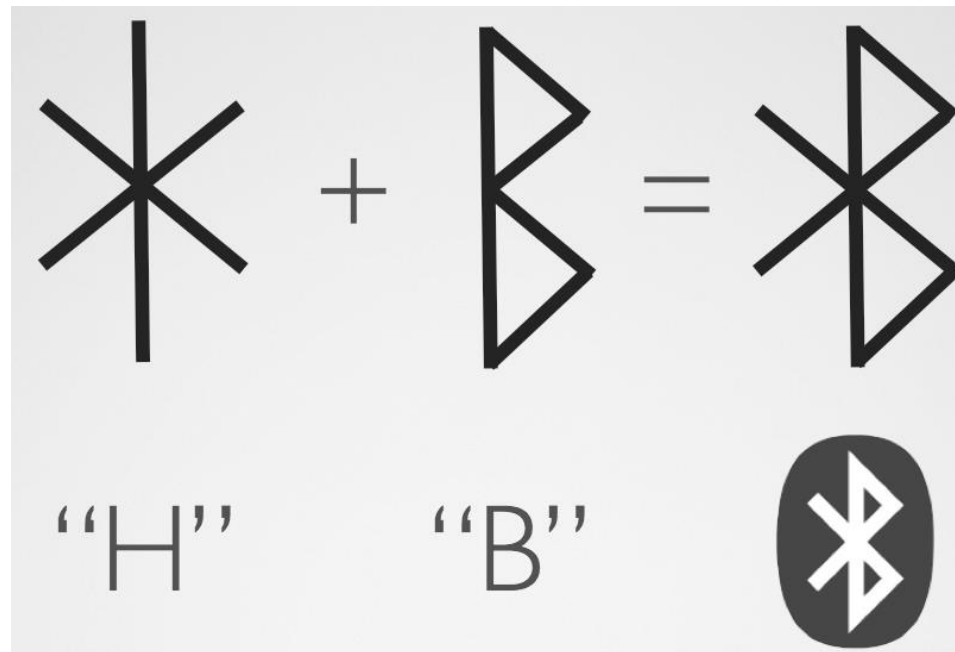
Bluetooth



- ❑ Bluetooth is a short-range wireless technology standard that is used for exchanging data between fixed and mobile devices over short distances using UHF radio waves in the ISM bands, from 2.402 GHz to 2.48 GHz.
- ❑ It is mainly used as an alternative to wire connections, to exchange files between nearby portable devices and connect cell phones and music players with wireless headphones.
- ❑ Many cars use Bluetooth to connect mobile phones to the entertainment system.
- ❑ In the most widely used mode, transmission power is limited to 2.5 milliwatts, giving it a very short range of up to 10 metres

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- ❑ Bluetooth uses a radio technology called frequency-hopping spread spectrum.
 - ❑ Bluetooth divides transmitted data into packets, and transmits each packet on one of 79 designated Bluetooth channels. Each channel has a bandwidth of 1 MHz.
 - ❑ It usually performs 1600 hops per second, with adaptive frequency-hopping (AFH) enabled.
 - ❑ Most Bluetooth applications are for indoor conditions, where attenuation of walls and signal fading due to signal reflections make the range far lower than specified line-of-sight ranges of the Bluetooth products.
 - ❑ While some desktop computers and most recent laptops come with Bluetooth built-in, others require an external adapter, typically in the form of a small USB "dongle."


- The Bluetooth logo is the combination of “H” and “B,” the initials of Harald Bluetooth, written in the ancient letters used by Vikings, which are called “runes.”



Near-Field Communication (NFC)




- Near-field communication (NFC) is a set of communication protocols that enables communication between two electronic devices over a distance of 4 cm or less.
- NFC offers a low-speed connection through a simple setup.
- Like other "proximity card" technologies, NFC is based on inductive coupling between two so-called antennas present on NFC-enabled devices—for example a smartphone and an EFTPOS machine.
- Communication can be in one or both directions, using a frequency of 13.56 MHz in the globally available unlicensed radio frequency ISM band using the ISO/IEC 18000-3 air interface standard at data rates ranging from 106 to 424 kbit/s.

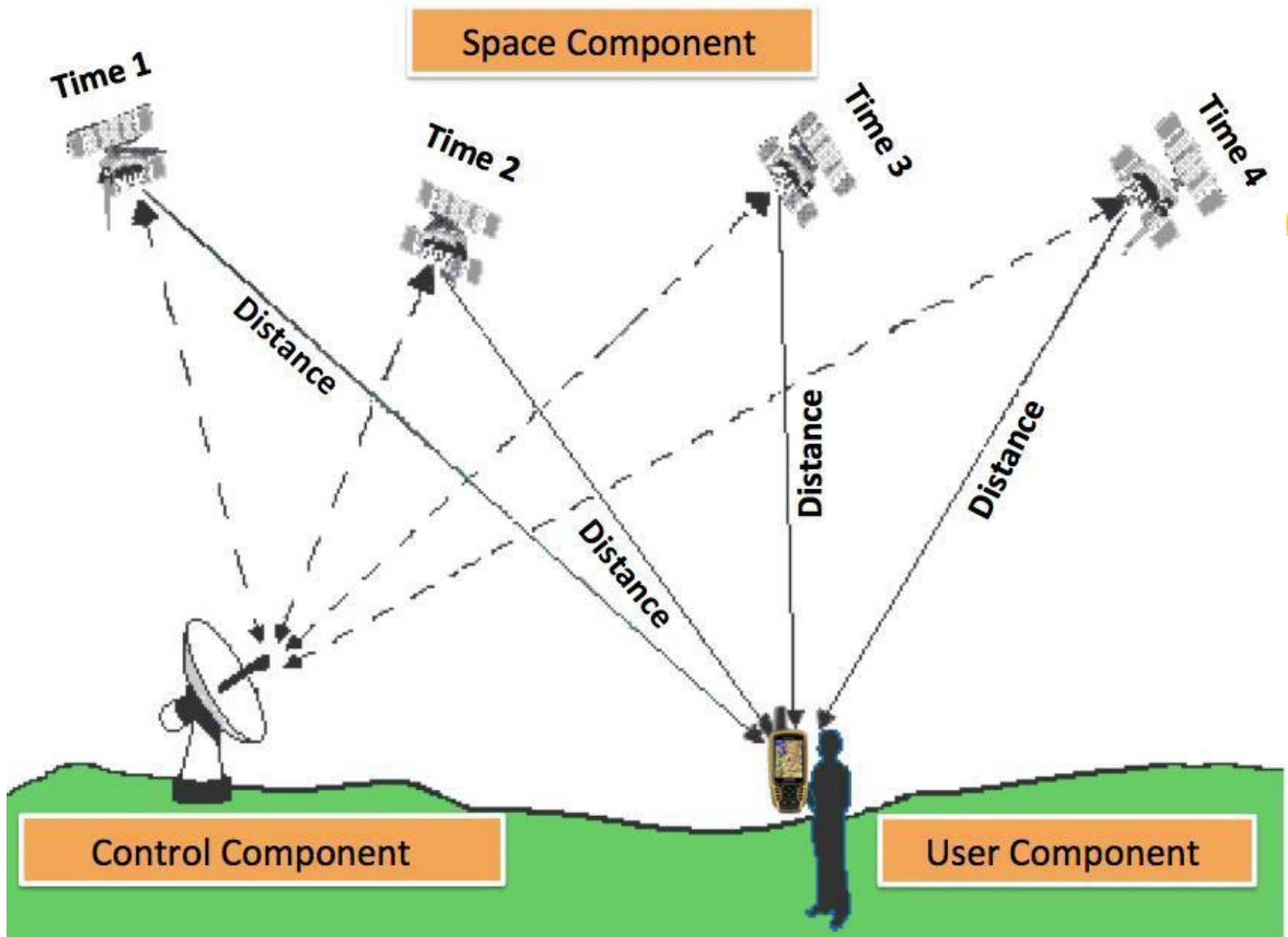
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- ❑ Secure communications are available by applying encryption algorithms as is done for credit cards.
 - ❑ NFC-enabled portable devices can be provided with application software, for example to read electronic tags or make payments when connected to an NFC-compliant system. These are standardized to NFC protocols, replacing proprietary technologies used by earlier systems.
 - ❑ NFC always involves an initiator and a target; the initiator actively generates an alternating magnetic field that can power a passive target. This enables NFC targets to take very simple form factors such as unpowered tags, stickers, key fobs, or cards.
 - ❑ NFC peer-to-peer communication is possible, provided both devices are powered.
 - ❑ As with proximity card technology, NFC uses inductive coupling between two nearby loop antennas effectively forming an air-core transformer.

GPS



- The Global Positioning System (GPS), originally Navstar GPS, is a satellite-based radio-navigation system owned by the United States government and operated by the United States Space Force.
- It is one of several global navigation satellite systems (GNSS) that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.
- Obstacles such as mountains and buildings can block the relatively weak GPS signals.
- **The GPS does not require the user to transmit any data**, and it operates independently of any telephonic or Internet reception, though these technologies can enhance the usefulness of the GPS positioning information.

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- GPS is a system. It's made up of three parts: satellites, ground stations, and receivers.
 - Satellites act like the stars in constellations—we know where they are supposed to be at any given time.
 - The ground stations use radar to make sure they are actually where we think they are.
 - A receiver, like you might find in your phone or in your car, is constantly listening for a signal from these satellites. The receiver figures out how far away it is from some of them.
 - Once the receiver calculates its distance from four or more satellites, it knows exactly where you are; latitude, longitude, and altitude. It also knows the exact time of day.



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- The GPS provides critical positioning capabilities to military, civil, and commercial users around the world.
- Other notable satellite navigation systems in use or various states of development include:
 - Beidou – system deployed and operated by the People's Republic of China, initiating global services in 2019.
 - Galileo – a global system being developed by the European Union and other partner countries, which began operation in 2016.
 - GLONASS – Russia's global navigation system. Fully operational worldwide.
 - NavIC – a regional navigation system developed by the Indian Space Research Organisation.
 - QZSS – a regional navigation system receivable in the Asia-Oceania regions, with a focus on Japan.